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(54) **Hybrid power transmission with power take-off apparatus**

Hybridantrieb mit Zusatzantrieben

Transmission hybride avec prises de force

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## Description

### TECHNICAL FIELD

- 5 [0001] This invention relates to hybrid power transmissions having power take-off apparatus for supplying power to auxiliary devices.

### BACKGROUND OF THE INVENTION

- 10 [0002] Hybrid power transmissions have at least two power sources, such as an internal combustion engine and an electrical source. The electrical source generally includes storage batteries and motor/generator devices. A power take-off (PTO) is provided to supply power to vehicle accessories.

- [0003] An electro-mechanical hybrid drive is for example known from EP-A-0 552 140 in which two motor/generators and an internal combustion engine are used as power source for a vehicle. The known electro-mechanical hybrid drive  
15 comprises an electrical power source and control means for connecting the power source with said motor/generators. Furthermore, a planetary gear arrangement is provided having three planetary members. The first planetary member is drivingly connected with the first motor/ generator and the second planetary member is drivingly connected with the second motor/generator. The third planetary member is selectively connectable with the internal combustion engine via a clutch.

- 20 [0004] Generally, the internal combustion engine is the power source for the accessory drive during start-up or initial vehicle operation. The accessories are required by the vehicle or transmission and not by the engine. For example, air conditioning, power steering and power brakes are available to provide satisfactory and comfortable vehicle operation. However, the engine power is not always needed nor desired during vehicle operating conditions; but at least some of the accessories are desired at this time. Generally, this has been accommodated by providing a separate  
25 battery and electrical motor drive for the accessories. The battery utilized for driving the engine accessories is charged from the engine power when the engine is operating. Such systems, however, surrender the most efficient accessory drive, that is, the engine drive.

### SUMMARY OF THE INVENTION

- 30 [0005] It is an object of the present invention to provide an improved accessory drive mechanism in combination with an internal combustion engine and an electric hybrid power transmission.

- [0006] In one aspect of this invention, a hybrid power transmission is provided with accessory or power take-off drive shafts. The PTO drive is connected through gearing to the engine portion of the summing planetary of the hybrid  
35 transmission. The other members of the summing planetary are connected to respective motor/generators devices.

- [0007] It is desirable to provide a clutch between the planetary member connectable with the engine and the engine. The clutch is available to disconnect the engine during electric only operation. During this operation, it is often necessary to operate the accessory drives. Therefore, the present invention connects the accessory drive shafts to the summing planetary on the transmission side of the input clutch rather than the engine side. With this aspect of the invention, the  
40 PTO can be engine driven, when the engine is operational, and by the electrical drive units when the engine is not operational.

- [0008] The speed of the motor/generator units, when operating in battery only, can be controlled to propel the vehicle and also drive the accessories. Also during electric only operation, the motor/generator units can be controlled such that the gear member of the summing planetary, which is to be connected with the engine clutch, can be driven at  
45 exactly the engine idle speed. The engine can thus be connected with the transmission system through synchronous engagement of the clutch. The elimination of slippage in the clutch during this engagement procedure lengthens the life of the clutch and improves the operating efficiency of the transmission.

### DESCRIPTION OF THE DRAWINGS

- 50 [0009] The drawing is a schematic representation of a hybrid power transmission and accessory drive.

### DESCRIPTION OF AN EXEMPLARY EMBODIMENT

- 55 [0010] The hybrid transmission 10 shown in the drawing includes a summing planetary gearing 12, a first motor/generator 14, a second motor/generator 16, an electrical control unit (ECU) 18, a battery or electrical storage system 20 and a pair of clutches 22 and 24.

- [0011] The summing planetary 12 includes a sun gear 26, a ring gear 28 and a planet carrier 30. The carrier 30

includes a plurality of pinion gears 32 which mesh with the sun gear 26 and ring gear 28. The carrier 30 has a hub portion 34 which provides a member for a fluid operated friction clutch 36. The input side of the clutch 36 is comprised of a hub 38 which is drivingly connected with an internal combustion engine 40.

[0012] Clutch 36 is a conventional fluid operated friction clutch, as are the clutches 22 and 24. As is well known, clutches have a slidably disposed piston which receives hydraulic fluid pressure in a control system, not shown, to cause selective engagement and disengagement of a plurality of interlaced friction plates. The clutch 36 can be engaged to provide a drive connection between the engine 40 and the planet carrier 30, or the clutch 36 can be disengaged to prevent the engine from supplying power whereby engine operation may be discontinued.

[0013] The sun gear 26 is drivingly connected with a spur gear or transfer gear 42 which in turn meshes with a transfer gear 44 which in turn meshes with a transfer gear 46. The transfer gear 46 is connected with the motor/generator unit 16 and the transfer gear 44 is connected with the input side of the clutch 24. The output side of clutch 24 is connected with a gear member 48 which in turn meshes with a gear 50 secured to drive continuously with an output shaft 52. The clutch 22 has an output side which is also connected with the gear 50.

[0014] The ring gear 28 is drivingly connected with a transfer gear member 54 which in turn meshes with an idler gear 56 which in turn meshes with a transfer gear 58. The transfer gear 58 is drivingly connected with the motor/generator unit 14 and the transfer gear unit 54 is connected with the input side of the clutch 22.

[0015] The transmission 10, when combined with the engine 40, provides a two-mode, input split, parallel hybrid transmission. The transmission will deliver power from either the engine in combination with the motor/generators 14 and 16 from the engine alone, or from the motor/generators 14 and 16 alone. The motor/generators 14 and 16 are controlled in speed and torque capabilities by the ECU 18.

[0016] The carrier 30 also has secured therewith a power take-off gear member 60. The gear member 60 provides power take-off from the hybrid transmission to a power take-off gear 62 which meshes with a power take-off gear 64 and a power take-off gear 66. The power take-off gear 66 in turn meshes with a power take-off gear 68. Thus, the power take-off gear 60 in effect drives four power take-off gears which are connected with respective power take-off shafts 70, 72, 74 and 76.

[0017] The power take-off shaft 70 drives a conventional PTO accessory member to which any mechanically driven apparatus, such as an external water pump, can be attached. The power take-off shaft 72 drives an air conditioning compressor and a power steering pump. The power take-off shaft 74 drives a sump pump 78 and a main transmission pump 80. The power take-off shaft 76 drives an air conditioner compressor for a vehicle air conditioning unit. The air compressor driven by the power take-off shaft 72 is operable to supply pressurized air to the vehicle for the operation of systems such as air brakes.

[0018] As previously mentioned, when the engine 40 is inoperative and the clutch 36 disengaged, the output shaft 52 can be driven solely by the motor/generators 14 and 16. Also, the motor/generators 14 and 16 can be operated without driving the output shaft 52 simply by disengaging both clutches 24 and 22. When the output of motor/generator 16 is desired to drive the vehicle, the clutch 24 is engaged and the clutch 22 is disengaged. When the motor/generator 14 is desired to drive the vehicle through output shaft 52, the clutch 22 is engaged while the clutch 24 is disengaged.

[0019] During the launch maneuver of the vehicle, the motor/generator 16 is connected through clutch 24 to the output shaft 52, while the clutch 22 is disengaged. With the vehicle at rest, the motor/generator 14 is driven at a predetermined speed while the motor/generator 16 is held at zero. With this accomplished, the clutch 24 is engaged with no slip. The motor/generator 16 can then be increased in speed to cause an increase in transmission output speed.

[0020] Also, under this condition, that is the motor/generator 16 being held at zero speed and the motor/generator 14 being driven by power from the batteries 20, the carrier 30 of the planetary gear set 12 can be driven at a predetermined speed. This predetermined speed is set to be equal to the idle speed of the engine 40. That is 1300 rpm in the preferred embodiment. With the carrier rotating at 1300 rpm and the engine 40 rotating at 1300 rpm, both sides of clutch 36 are rotating at 1300 rpm.

[0021] With the PTO shaft 74 being driven, the main transmission 80 will provide fluid pressure through a control, not shown, to cause engagement of clutch 36. Since both sides of the clutch 36 are operating at the same speed, the clutch is engaged synchronously without slipping or torque transmission being undertaken. After the clutch 36 is engaged, both the speed of engine 40 and the speed of motor/generator 16 can be increased thereby increasing the output speed of the vehicle.

[0022] It is important to note that the clutch 36 is engaged synchronously and it is likewise important that all of the accessories can be driven by the motor/generators 14 and 16 without any input from the engine 40. It should also be apparent that the engine 40, when the clutch 36 is engaged, will supply power to the gear 60 and therefore to the power take-off shafts 70, 72, 74 and 76 through their respective members. Thus, during engine operation, all of the accessory drive power can be provided by the engine thereby relieving the motor/generators 14 and 16 of this duty. This provides for the most efficient operation of the accessory units when a vehicle incorporating the hybrid transmission 10 and accessory drive package incorporated therewith is operating at highway speeds where the engine 40 is operated. However, the vehicle does not sacrifice the loss of accessory drive when the engine 40 is inoperable, since, as pointed

out above, the accessories can be operated wholly by the motor/generators 14 and 16.

[0023] The following chart provides gear tooth and speed values for the synchronous engagement of clutch 36.

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	Teeth	RPM
Engine	N/A	1300
Carrier 30	N/A	1300
Gear 26	55	0
" 28	119	1900
" 42	102	0
" 44	106	0
" 46	32	0
" 54	95	1900
" 58	32	5643
" 60	128	1300
" 62	117	1422
" 64	114	1460
" 66	54	3181
" 68	67	2484
Motor/Gen. 14	N/A	5643
" 16	N/A	0

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[0024] Obviously, many modifications and variations of the present invention are possible in light of the above teaching. It is therefore to be understood, that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

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#### Claims

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#### 1. An electro-mechanical hybrid drive comprising:

an electrical power and storage source (20);

a first motor/generator (14);

a second motor/generator (16);

control means (18) for selectively connecting said power and storage source with said first and second motor/generators for controlling their respective operation thereof;

an internal combustion engine prime mover (40) having an idle speed;

a planetary gear arrangement (12) having a first member (28) drivingly connected with said first motor/generator, a second member (26) drivingly connected with said second motor/generator; and

a hydraulically operated clutch (36) which is selectively engageable to connect said prime mover with a third planetary member (30) of said planetary gear arrangement (12); characterized in that said third member (30) being drivingly connected with a plurality of accessory drive shafts (70,72,74,76), one of which is drivingly

connected with a hydraulic power source; and  
 said first and second motor/generators being operable through said planetary gear arrangement (12) to operate  
 said hydraulic power source and to control the speeds of the first and second members (26,28) to rotate said  
 third member (30) of said planetary gear arrangement (12) at a speed proportional to said idle speed when  
 said clutch (36) is disengaged to permit selective engagement of said clutch (36) at a speed synchronous with  
 said idle speed.

2. The electro-mechanical hybrid drive defined in Claim 1, characterized in that said first member is a ring gear, said  
 second member is a sun gear and said third member is a planet carrier.

3. The electro-mechanical hybrid drive defined in Claim 1, characterized in that the speed of the second member is  
 zero when the third member is proportional to said idle speed.

## Revendications

1. Dispositif d'entraînement électromécanique hybride comprenant :

une source d'énergie électrique et de stockage (20);  
 un premier moteur/générateur (14) ;  
 un second moteur/générateur (16);  
 des moyens de commande (18) pour raccorder de façon sélective ladite source d'énergie et de stockage  
 auxdits premier et second moteurs/générateurs pour commander leur fonctionnement respectif;  
 une machine motrice (40) formée d'un moteur à combustion interne et possédant une vitesse de ralenti;  
 un dispositif d'engrenage planétaire (12) possédant un premier élément (28) raccordé selon une liaison motrice  
 audit premier moteur/générateur, un second élément (26) raccordé selon une liaison motrice audit second  
 moteur/ générateur; et  
 un embrayage à commande hydraulique (36), qui peut être enclenché sélectivement pour raccorder ladite  
 machine motrice à un troisième élément planétaire (30) dudit agencement d'engrenage planétaire (12);

caractérisé en ce que

ledit troisième élément (30) est raccordé selon une liaison motrice à une pluralité d'arbres d'entraînement  
 secondaires (70,72,74,76), dont l'un est raccordé selon une liaison motrice à une source d'énergie hydraulique;  
 et  
 lesdits premier et second moteurs/générateurs pouvant agir par l'intermédiaire dudit dispositif d'engrenage  
 planétaire (12) pour actionner ladite source d'énergie hydraulique et commander les vitesses des premier et  
 second éléments (26,28) pour faire tourner ledit troisième élément (30) dudit dispositif d'engrenage planétaire  
 (12) à une vitesse proportionnelle à ladite vitesse de ralenti lorsque ledit engrenage (36) est désenclenché  
 de manière à permettre un enclenchement sélectif dudit embrayage (36) à une vitesse synchrone à ladite  
 vitesse de ralenti.

2. Dispositif d'entraînement électromécanique hybride selon la revendication 1, caractérisé en ce que ledit premier  
 élément est une couronne dde train planétaire, que ledit second élément est une roue solaire et que ledit troisième  
 élément est un porte-pignons satellite.

3. Dispositif d'entraînement électromécanique hybride selon la revendication 1, caractérisé en ce que la vitesse du  
 second élément est nulle lorsque ledit troisième élément est proportionnel à ladite vitesse de ralenti.

## Patentansprüche

1. Elektromechanischer Hybridantrieb, umfassend:

eine elektrische Energie- und Speicherquelle (20),

einen ersten Motor/Generator (14),

einen zweiten Motor/Generator (16),

ein Steuermittel (18), um die Energie- und Speicherquelle selektiv mit dem ersten und dem zweiten Motor/Generator zu verbinden, um deren jeweiligen Betrieb zu steuern,

eine Verbrennungsmotor-Antriebsmaschine (40) mit einer Leerlaufdrehzahl,

eine Planetengetriebeanordnung (12) mit einem ersten Element (28), das in Antriebsverbindung mit dem ersten Motor/Generator steht, einem zweiten Element (26), das in Antriebsverbindung mit dem zweiten Motor/Generator steht, und

eine hydraulisch betätigte Kupplung (36), die selektiv in Eingriff gebracht werden kann, um die Antriebsmaschine mit einem dritten Planetengetriebeelement (30) der Planetengetriebeanordnung (12) zu verbinden,

dadurch **gekennzeichnet**, daß

das dritte Element (30) in Antriebsverbindung mit mehreren Antriebswellen für Zusatzeinrichtungen (70, 72, 74, 76) steht, von denen eine in Antriebsverbindung mit einer hydraulischen Energiequelle steht, und

daß der erste und der zweite Motor/Generator über die Planetengetriebeanordnung (12) betrieben werden können, um die hydraulische Energiequelle zu betätigen und um die Drehzahlen des ersten und des zweiten Elements (26, 28) zu steuern und somit das dritte Element (30) der Planetengetriebeanordnung (12) mit einer Drehzahl zu drehen, die proportional zur Leerlaufdrehzahl ist, wenn die Kupplung (36) außer Eingriff steht, um einen selektiven Eingriff der Kupplung (36) mit einer Drehzahl zu gestatten, die synchron mit der Leerlaufdrehzahl ist.

2. Elektromechanischer Hybridantrieb nach Anspruch 1, dadurch **gekennzeichnet**, daß

das erste Element ein Hohlrad ist, das zweite Element ein Sonnenrad ist und das dritte Element ein Planetenradträger ist

3. Elektromechanischer Hybridantrieb nach Anspruch 1,

dadurch **gekennzeichnet**, daß die Drehzahl des zweiten Elements null ist, wenn diejenige des dritten Elements proportional zur Leerlaufdrehzahl ist.

